Fish Raceway or Tank (m, ft and m^3/s, ft^3/s)

Definition

A channel or tank with a continuous flow of water constructed or used for high-density fish production.

Scope

This standard applies to raceways or tanks that conduct flowing water to produce fish. It applies to earthen channels as well as those channels and tanks constructed of concrete, concrete block, timber, rock, fiberglass, or other materials. It does not apply to hatchery operations that utilize troughs or barrels and are primarily indoors.

Purpose

To provide a facility containing flowing water of a suitable temperature and quality for dependable production of fish; to manipulate the chemical, physical, and biological factors to enhance fish production, and to maintain water quality.

Conditions where practice applies

Where water and land resources are suitable for constructing a raceway or tank that can be used to produce a commercial fish crop.

Planning considerations

The cooperator's objective as well as the limitations and potentials of available aquaculture resources will dictate the level of development and management to be planned. An aquaculture resource assessment must be made to determine the feasibility of the raceway or tank culture system. Planning is complete when all practice components essential to reaching the cooperator's management objectives and maintaining the water resource have been identified.

Design criteria

The facility must be designed to provide protection from flooding, sedimentation and contamination by pollutants from outside sources.

Fish raceways are generally constructed as 1) linear channels where water flows in at one end and exits at the other end or 2) as circular, rectangular, or oval tanks where water enters through nozzles or jets in a manner that creates a rotary circulation within the tank and discharge typically is through the tank center by means of a standpipe or bottom drain. The raceway dimensions shall be designed based upon the available water and planned production level.

Water requirements

A Quantity—A water supply of sufficient volume must be available either by gravity or by pumping. For linear raceways, there shall be a continuous incoming water supply to provide a minimum velocity of 0.015 m/s (0.05 ft/s) flowing at a minimum average depth of 0.6 m (2 ft). This is approximately two complete water exchanges per hour for a raceway length of 25 to 30 m (80 to 100 ft). The water volume shall be measured during periods of low flow.

B Quality—Water must be free of harmful gases, minerals, silt, pesticides, and other pollutants. A water analysis shall be made before design and construction unless previous use or experience indicates the quality is satisfactory. Water quality requirements for trout and catfish are shown in table 1.

Table 1.—Water quality requirements

Quality parameter		Species	
		Trout	Catfish
Dissolved oxygen—	Desirable	8 ppm or more	5 ppm or more
	Minimum	5 ppm	3 ppm
Temperature—	Desirable	12.8 to 17.8°C (55-64°F)	23.9 to 28.9°C (75-84°F)
	Minimum/ maximum	7.2/21.1°C (45/70°F)	15.5/32.2°C (60/90°F)
pH—	Desirable	6.5-9.0	6.5-9.0
	Minimum/ maximum	6.0/9.5	6.0/9.5
Carbon dioxide—	Desirable	2 ppm or less	5 ppm or less
	Minimum*/ maximum	0/3 ppm	0/10 ppm

*Toxicity varies with dissolved oxygen concentration and temperature

Linear Channel Raceways

Channel raceways are generally of two types: a) concrete or concrete block construction and b) earthen channels constructed with a trapezoidal or parabolic cross section.

a) Concrete or concrete block raceways shall be designed and constructed according to established principles and techniques outlined in the National Engineering Manual (NEM), ACI Code, Masonry Handbook, or other approved guides as appropriate. Where concrete or concrete block raceways are installed, the bulkheads or checkdams must be of the same construction.
b) Earthen channel raceways shall be constructed with a trapezoidal or parabolic cross section. Bottom widths depend on the volume of water available but shall be no less than 1.2 m (4 ft). Side slopes shall be 1:1 or flatter depending on a saturated soil slope stability analysis. Side slopes and bottoms of raceways must be smooth and uniform to minimize dead water areas.

Grade. Wherever possible, raceways shall be constructed with a minimum bottom grade of 0.15 m per 30 m (0.5 ft per 100 ft). The raceway outlet will control the water surface grade.

Length. The maximum length of each raceway section is determined by site topography and need for re-aeration of the water but should not exceed 30 m (100 ft). Depending on water volume and quality, raceway sections may be constructed in series by installing a bulkhead or checkdam at the lower end of each section.

Freeboard. The minimum difference in elevation between the water surface in the raceway and the top of the bulkhead, dike, or levee alongside the raceway is 0.15 m (0.5 ft).

Dikes and levees. The minimum top width of an earthen dike or levee shall be 1.8 m (6 ft). Side slopes of earthen dikes and levees above the designed water surface shall be 2:1 or flatter. When the top of the dike or levee is to be used for a road, the minimum top width shall be 4.3 m (14 ft).

Bulkheads. Structural or earthen barriers called bulkheads are to be placed across raceway channels to create shorter sections, to establish and maintain the desired water levels, and to provide aeration of the water. In addition to serving as a barrier, they shall have an opening or throat section that allows complete drainage to the bottom of the raceway channel unless other drainage facilities are provided. Bulkheads may be constructed of earth, concrete, concrete block, rock masonry, steel or other durable metal, treated timber, or combinations of these. Earthen bulkheads are to have a minimum top width of 1.2 m (4 ft) and side slopes of 2:1 or flatter. Structural bulkheads used in earthen raceways must extend at least 61.0 cm (24 in) into the sides and bottom of the channel. Concrete bulkheads shall have a minimum top width of 15 cm (6 in) and a minimum bottom width of 20 cm (8 in). Openings and cores in concrete blocks shall be filled with either concrete or mortar mix. The opening or throat section of bulkheads may be constructed of concrete, concrete block, wood, or metal. It shall have slots or grooves along the vertical face that allow flashboards and screens to be installed.

Drains. A pipe drain with a minimum diameter of 15 cm (6 in) shall be provided at the bottom of the bulkhead unless flashboards used to establish the desired water level can be removed to provide complete drainage. Where possible, each unit in a series should be constructed so that it can be drained independently of the other units.

Screens. Screens shall be provided at the inlet of the system if necessary to exclude wild fish. Screens shall also be placed at each bulkhead between sections and at the exit end to prevent loss of fish. They shall be placed at least 15 to 20 cm (6 to 8 in) upstream from the flashboards and shall extend at least

15 to 20 cm (6 to 8 in) above the expected water level to prevent fish from escaping by jumping.

Aeration. Each bulkhead shall be fitted with a weir overfall. Flashboards in the opening or throat section of the bulkhead may be used for this purpose. The width of the weir or weirs should be equal to the bottom width of the raceway but shall not be less than 1.2 m (4 ft) where flashboards are used to establish the desired water level. Two or more weirs separated by rigid center sections shall be installed when the width of the raceway exceeds 2.4 m (8 ft). To increase aeration, a splash board or series of boards arranged to create successive splashes shall be considered in design. The minimum distance from the weir crest to the water level below should be no less than 0.31 m (1 ft).

Tank Raceways

Tank raceways are circular, rectangular, or oval and are constructed of concrete, metal, fiberglass, or other suitable material. Fiberglass and a variety of similar materials commonly referred to as "plastic" tanks are generally suitable if construction and support are sufficient to provide strength and durability. Noncircular tanks must have an interior dividing wall to obtain proper circulation. Tank raceways shall be constructed at locations accessible to water supplies, management personnel, and feed and harvest equipment.

Water supply. Water inlets to the tank may be through jets or nozzles or similar devices that provide a tangential force to the water in the tank. These nozzles should be located above the water surface to provide aeration. They may be submerged but should not be near the bottom because of the problem of uplift of waste particles. The nozzles shall be positioned so that flow in the tank is counterclockwise to take advantage of the natural tendency for water in North America to rotate in this direction.

Waste removal. Provisions for waste removal shall be incorporated in the design. Bottom troughs, screens, or center-positioned drain pipe shall be provided as part of the tank construction.

Factors applicable to raceways and tanks

Predators. Fences, screens, nets, wires, or other materials shall be provided as needed to prevent the loss of fish to predators. Traps or other devices that are potentially harmful for humans, livestock, or pets shall be placed only in secure locations not normally accessible except through special effort.

Waste treatment. Plans for treatment or use of waste that are generated or caused by the operation of fish raceways or tanks shall be developed and made a part of the design and installation of the practice. The treatments will include the construction of waste storage ponds, storage structures, treatment lagoons, settling basins, or other facilities. Waste utilization by the spreading of waste on land through irrigation or hauling is permissible if soils and land resources are available. Discharges into streams must meet state standards for the stream, based on size of operation, and comply with National Pollutant Discharge Elimination System (NPDES) regulations.

Protection. A protection cover of vegetation shall be established on all exposed surfaces that have been disturbed. If soil or climatic conditions preclude the use of vegetation, other methods may be used for protection. Adequate provisions must be made to protect earth surfaces from wave erosion. Fences shall be installed as necessary. Road surfaces along raceways and the outer perimeter of tanks shall be treated as needed to provide access and reduce erosion. Dikes and levees should be crowned to provide drainage.

Operation and maintenance

A plan shall be prepared that provides for inspection, operation, and maintenance of vegetation, pipes, valves, raceways, tanks, dikes, levees, bulkheads, and other parts of the system.

Plans and specifications

Plans and specifications for constructing raceways and tanks and their appurtenances shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Fish Raceway or Tank Specifications

Engineering specifications

Clearing. All trees, brush, logs, stumps, roots, loose boulders, or other debris shall be cleared from the raceway or tank construction area and from the area where fill is to be placed for dikes or levees. If needed to establish vegetation, the topsoil and sod shall be stockpiled and later spread on the completed surfaces.

Excavation. All excavation necessary for the construction of raceways, bulkheads, or tank foundation and footings shall be performed in a workmanlike manner to the lines and grades shown on the drawings or as staked in the field.

Fill placement. The material placed in the dikes or levees shall be free of sod, roots, frozen soil, boulders larger than 15 cm (6 in) in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation, and the fill shall be brought up in approximately horizontal layers of such thickness that the required compaction can be obtained with the equipment used.

Compaction. The moisture content of the fill material shall be adequate for obtaining the required compaction. Construction equipment shall be operated over each layer of fill to ensure that the required compaction is achieved. Earth fill placed in close proximity to structures and pipelines shall be compacted using hand tampers or manually operated power tampers or vibrators.

Concrete. Concrete shall receive the detail in mix design and testing consistent with the size and requirements of the job. Mix requirements or necessary strength should be specified. Type of cement, air entrainment, slump, aggregate, or other properties are to be specified where necessary.

All concrete is to be placed, finished, and cured in an acceptable manner. Reinforcing steel is to be placed as indicated on the plans and held securely in place during concrete placement. Subgrades and forms are to be installed to line and grade as shown in the drawings, and the forms are to be mortar tight and unyielding as the concrete is placed.

Concrete tanks shall have a minimum thickness of 15 cm (6 in) and shall be steel reinforced. They shall have concrete bottoms. All interior surfaces shall be smooth and treated with epoxy sealer or other suitable material to permit sterilization. Washing new concrete tanks with acetic acid is recommended.

Wood construction and metal fabrication. All untreated wood construction, metal fabrication, and other miscellaneous materials such as screens, flashboards, splashboards, and inlet structures that are used in small quantities and are readily replaceable shall be of durable quality. All fabrication of materials will have a good workmanlike appearance.

Metal tanks will be assembled or installed according to manufacturers recommendations. The interior surface will be painted or treated with an epoxy coating or other suitable material that will preserve the metal and be compatible with fish culture. Where the tank's interior surface is rough or contains fiberglass matting, it must be covered or sealed with an approved resin or sealer.

Overall quality and workmanship. Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution are minimized and held within legal limits. All work will be conducted in a skillful and workmanlike manner.

The completed job shall present a workmanlike appearance. Fencing and vegetative cover to control erosion and pollution shall be established as needed. Appropriate safety measures such as warning signs, rescue facilities, guardrails, and fencing shall be provided as specified.

Biology specifications guide

The practice specifications shall include the minimum biological requirements of each aquaculture species that is to be grown under these types of culture systems. The limits of essential water quality parameters shall be defined for each cultured species.

Fish Raceway or Tank (m, ft, and m^3/s, ft^3/s)

Planning considerations for water quantity and quality

Quantity

1. Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.

2. Effects on downstream flows and aquifers that would affect other water uses.

3. Effects on the volume of downstream flow that might cause undesirable environmental, social, or economic effects.

Quality

1. Effects on the visual quality of downstream water resources.

2. Short-term and construction-related effects on the quality of the onsite and downstream water.

3. Effects on the movement of dissolved substances below the root zone and toward the ground water.

4. Effects on wetlands and water-related wildlife habitats.

FISH RACEWAYS

Standards

Definition: A channel with a continuous flow of water constructed to produce fish.

Purpose: To provide a water area with rapid exchange of water for producing fish.

Where Applicable: On land where water resources and topography are suitable for constructing a raceway.

Specifications for a given installation must conform to the preceeding standards.

Design Criteria

I. Refer to Management Guide, "Raceway Management for Trout in Montana" for design criteria.

Environmental Criteria

I. Water should be from wells or springs, where possible, to prevent disease and parasite contamination from wild fish populations.

II. Water quality for trout must be analyzed prior to construction. Acceptable water quality criteria are as follows:

A. Temperature of water should be between 50 degrees Fahrenheit and 65 degrees Fahrenheit at the source; 70 degrees Fahrenheit is maximum anywhere in the raceway.

B. Dissolved oxygen content - 100 percent saturation is preferable; 7 ppm or higher is necessary at the beginning of each raceway section. At no time or location should the level fall below 5 ppm.

C. The pH of water should range between 6.5 and 9.0.

D. A water hardness of at least 50 ppm is necessary for successful fish production.

E. Waters should be free of pollutants, debris, sediment, or harmful gases.

II. Water quantity - one hundred gallons per minute (g.p.m.) is the minimum flow around which to develop a production unit..

IV. Consult with the State Biologist during the planning phase prior to design and construction.

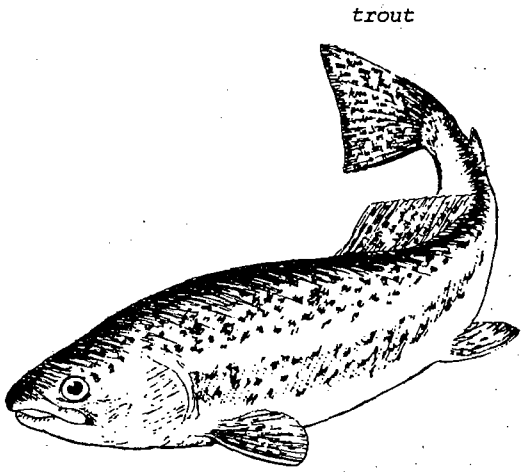
These specifications apply to SCS operations in all current programs. Specifications developed by Soil Conservation Service, USDA.

Concurred in: Montana Fish and Game Department

398

Raceway management for

TROUT



trout

IN MONTANA

A raceway is one type of rearing pond used in trout production. It is a rectangular or trapezoidal channel of water which may be one of a stair-step series or by itself. Water depth is shallow, thus the volume of water per unit of area is relatively small. The design provides for a current of water moving through it at all times, thus giving it the name "raceway."

Raceways are used for rearing trout where artificial food is supplied to produce more pounds of fish than can be produced by the natural fertility of spring water.

Trout have the same physiological requirements regardless of whether they are being reared in a stream, pond, or raceway. Refer to habitat management guide, "Pond Management for Rainbow Trout in Montana," for trout culture in ponds.

WATER SUPPLY. A water supply of sufficient volume and suitable quality must be available for rearing trout in a raceway. The water should not be warmer than 65 degrees Fahrenheit at the source, thus allowing a 5-degree increase up to 70 degrees before the water becomes undesirable.

Temperatures should be measured during the warmest time of the year, which is generally from July to September. Warm surface water and water laden with silt should not be allowed to contaminate the raceway water at any time. Hard water is best for trout rearing and for rainbow trout it is essential. Better results are obtained when water is kept on the alkaline side.

Springs, wells, and cold water streams are good sources of water. However, each of them may have some undesirable features. The quality of any source of water should be analyzed carefully for at least one summer's season before deciding to utilize it for a trout raceway. Springs are generally very suitable in temperature, but some may be slightly acid. Those coming from sandstone will be soft. Springs in limestone sections will be hard water, but sometimes will receive warm surface water from a sinkhole somewhere along its underground course.

Wells will have about the same possibilities as springs, depending on the type of stratum yielding the water. Well water usually has a high content of undesirable dissolved gases and little, if any, oxygen. The gases can be released and oxygen instilled by aeration before entering the raceway. Streams may be warmed too much by runoff from warm summer rains--an always present hazard.

The base flow of a source of water should be determined. This is essential in determining the potential development of the project. One hundred gallons per minute (gpm) is about a minimum flow desired for a raceway. At the present time, it is believed that it would not be practical to develop a production unit around a flow of any less volume. Measure the volume of flow during the period of lowest flow. This will normally be from July through September with expected variations.

USDA-SCS-PORTLAND, OREG. 1973

Frequently the most desirable site for a raceway is not in exactly the same spot as the water source. Pipe is the best method of conveying water from the source (spring, stream, or well) to the use area. A minimum rise of water temperature and loss of volume is assured by this method. All pipe should be buried to a minimum depth of two feet to avoid freezing, warming, or damage from cultivation. Do not use galvanized pipe.

TYPES OF RACEWAYS. The two raceways that receive the most emphasis at the present time are: (1) the concrete or concrete block raceway, and (2) the earth raceway. (Detailed designs of these are available. A copy of each is attached.)

The basic factors that will determine the carrying capacity or production of a raceway are water volume, temperature, and oxygen. Other factors such as water quality, rate of flow, rate of change, re-use of water, kind of fish and size of fish are also important factors.

Concrete or Concrete Block Raceways. Masonry raceways have been used in rearing trout for many years. They are the most expensive type of installation and all the food for the fish has to be provided. However, in comparison to earth raceways, they make more efficient use of water, are easier to keep clean, and less trouble develops with aquatic vegetation. The bottom of the raceway is more stable in presence of a current, has better food distribution characteristics, and is easier to clean.

See attached standard plans for concrete and concrete block raceways for trout. Consult *SCS Engineering Handbook* for any necessary structural changes in these plans.

Masonry raceways should be designed with a bottom slope of 0.5 percent and should not be over 100 feet long. This is about as far as the water should travel before it needs to be re-aerated by letting it fall at least six inches into another raceway. To increase oxygen content, an overfall of six to 12 inches at 50-foot lengths may be desirable in sites of lower quality water or to better fit the contour of the land.

The water in a raceway need not be over two feet deep at the lower end, but may be as much as three feet. Drop-boards for controlling the water level should be constructed at the lower end of the raceway with a screen on the upstream side of the drop-boards. Leave a 12- to 18-inch space between the screen and boards.

The width of the raceway will depend upon the volume of water available and amount of fish to be produced. If full capacity is desired, design the width for a velocity of 0.05 feet per second. Calculate this velocity about halfway between the intake and outlet. Use the simple formula $Q = AV$; Q is the volume of flow in cubic feet per second; A is the area of water in square feet at that point; and V is the velocity. This is not too much velocity for young fish, but is enough to remove free swimming parasites. The velocity of the water through the raceway can be increased by removing control boards to make it shallower. This will be needed when cleaning the raceway frequently.

Earth Raceways. Earth raceways are cheaper to install but still require a section of concrete for the water control structure. Earth raceways are apt to grow aquatic vegetation and are more difficult to clean than concrete types.

Earth raceways should be constructed with 0.5 percent fall and with a trapezoidal shape. The minimum velocity should be 0.05 foot per second, the same as masonry or concrete raceways. Use a minimum sized gravel or limestone aggregate of one inch to cover the bottom.

The concrete control at the lower end of the raceway should have a throat as wide as the bottom width of the raceway. The throat should be at least as long as it is wide. This size of throat is desirable to provide an area of hard bottom to handle fish and to provide good aeration for the next raceway below. At the top of the throat and at the lower end, wing walls should extend at a 45-degree angle to the raceway into solid ground or at least into the raceway banks. The lower end of the throat should be

equipped with drop-boards for controlling water level and a screen. Leave a 12- to 18-inch space between the drop-boards and the screen with the screen located upstream from the boards. Construct by leaving slots in the concrete two inches deep and 2-1/8 inches wide.

Heavy plastic could be used in the bottom and sides of earth raceways where there is excessive loss of water due to seepage.

RACEWAY SIZES AND ESTIMATED PRODUCTION. Raceway size and production will vary with the volume and quality of water flowing through the raceway. The exact carrying capacity of any one area will have to be determined through experience with conditions that exist at that site.

ESTIMATED ANNUAL TROUT PRODUCTION IN RACEWAYS

Water Supply 1/ *cfs*	*gpm*	*Annual Production* 2/ *Lbs/100' Section*	*Bottom Width (feet)*	*Maximum Water Depth (feet)*	*Raceway Shape*
0.3	135	600 to 960	3	2	Vertical sides (concrete or block)
0.4	180	800 to 1,280	4	2	"
0.5	225	1,000 to 1,600	5	2	"
0.6	270	1,200 to 1,920	6	2	"
0.7	315	1,400 to 2,240	7	2	"
0.8	360	1,600 to 2,560	8	2	"
0.9	405	1,800 to 2,880	9	2	"
1.0	450	2,000 to 3,200	10	2	"
0.7	315	1,400 to 2,240	3	2	Trapezoidal
0.8	360	1,600 to 2,560	4	2	2:1 side slopes
1.0	450	2,000 to 3,200	6	2	"
1.2	540	2,400 to 3,840	8	2	"
1.4	630	2,800 to 4,480	10	2	"
1.5	675	3,000 to 4,800	4	3	Trapezoidal
1.8	810	3,600 to 5,760	6	3	2:1 side slopes
2.1	945	4,200 to 6,720	8	3	"
2.4	1,080	4,800 to 7,680	10	3	"

1/ *Average water velocity in raceway--0.05 feet per second or two water changes per hour per 100-foot raceway.*

2/ *Range of production 1 to 1.6 pounds per cubic foot of water. (The first column can also be read as static cubic feet.)*

FISH MANAGEMENT. The size and total poundage to be produced will determine how many fish to stock in a raceway. From the preceding criteria, determine the estimated pounds of fish the raceway will produce. Divide this by the size (weight) of fish desired and add 20 percent more to allow for expected mortality. This will be the number of small fish to stock. Harvest the fish as soon as they have grown to a harvestable or marketable size.

There is a difference of opinion as to what size of fish to stock in a raceway. Fingerlings two to three inches in size are cheaper to buy and easier to transport.

Fingerlings or fry for stocking raceways can be purchased from commercial hatcheries. To decrease transportation costs, small orders should be pooled.

Always use feed specifically prepared for trout. Good trout food is available from commercial sources and can be purchased with or without antibiotics. Costs can be decreased by large orders; therefore, it is beneficial to pool shipments wherever possible.

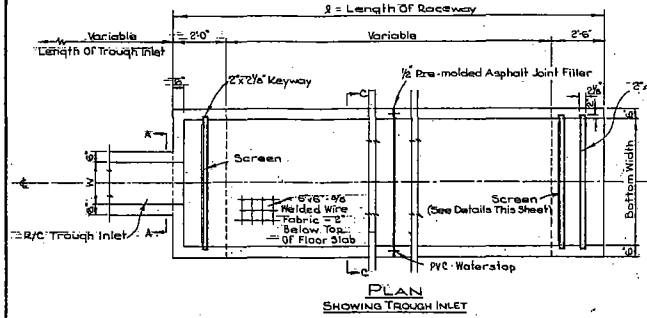
Rate and quantity of feeding will vary with the water temperature, size, and number of fish stocked. Generally, trout fry should be fed about five times daily, small fingerlings about four times daily, medium and large fingerlings two to three times a day, and adults once or twice a day. Food should be fed in accordance with the amount that the trout will consume promptly at one feeding. A daily feeding rate of approximately three to five percent of the total weight of the fish may be used. In other words, 100 pounds of fish would receive three to five pounds of feed per day. Compute total weight of fish in the pond using the following table:

If length of trout is:	1"	2"	3"	4"	5"	6"	7"	8"	9"	10"
The number of fish per lb. will be:	2500	300	90	40	20	12	7	5	4	3

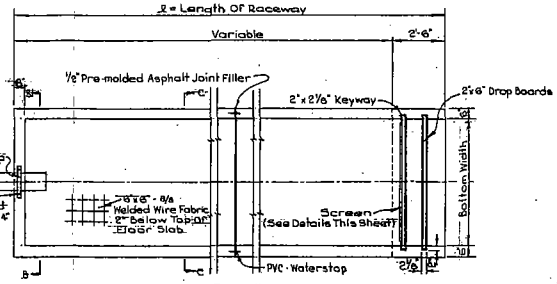
Charts are available from the Soil Conservation Service State Biologist which offer guides for more precise feeding of various size groups of trout at different water temperatures. When water temperatures go below 50 degrees Fahrenheit, trout tend to taper off in feeding consumption; decrease feed accordingly. Overfeeding can create a water oxygen shortage because of decomposition of unused feed.

RACEWAY DISCHARGE PERMIT. Permits are now required by the Environmental Protection Agency for discharge of waters from commercial fish production facilities into streams or waters which eventually reach a navigable stream. Application should be made to the Environmental Protection Agency, Denver, Colorado.

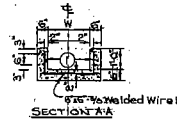
PRIVATE POND LICENSE. A private fish pond license is required by the Montana Department of Fish and Game prior to stocking fish in ponds or raceways in the state.



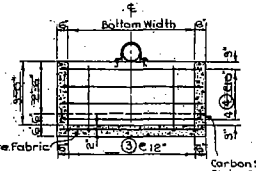
PLAN
SHOWING TROUGH INLET



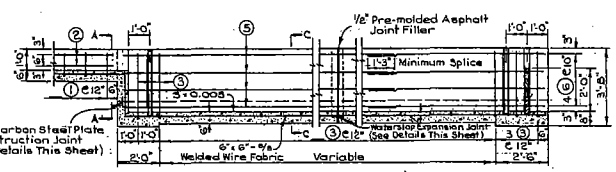
PLAN
SHOWING PIPE INLET



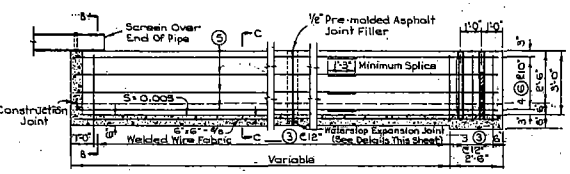
SECTION A-A



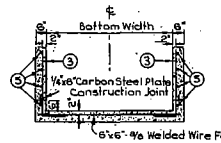
SECTION B-B



SECTION ALONG ℄
SHOWING TROUGH INLET

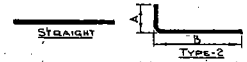


SECTION A'ALONG ℄
SHOWING PIPE INLET

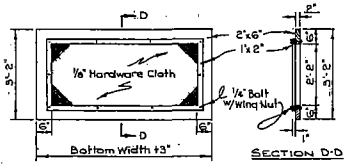


SECTION C-C

BAR TYPES

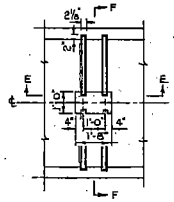


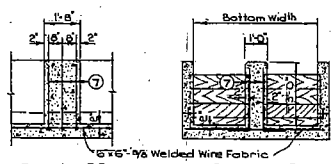
NOTE: Minimum Radius Of All Bends To Be 4 Times Bar Diameter



SECTION D-D

DETAILS OF SCREEN





SECTION E-E

SECTION F-F

NOTE: When Bottom Width Exceeds 6'-0" - A Reinforced Concrete Post Shall Be Placed In The Center Of The Raceway At All Screen & Drop Board Sections

DETAILS OF REINFORCED CONCRETE POST

ISOMETRIC VIEW
SHOWING TROUGH INLET

QUANTITIES FOR RACEWAY	
BOTTOM WIDTH IN-FEET	VOLUME OF CONCRETE IN CU.YDS., WHEN ℓ = LENGTH OF RACEWAY IN-FT.
3	0.17 + 0.1852 ℓ
4	0.22 + 0.2037 ℓ
5	0.28 + 0.2222 ℓ
6	0.33 + 0.2407 ℓ
7	0.39 + 0.2593 ℓ
8	0.44 + 0.2778 ℓ
9	0.50 + 0.2963 ℓ
10	0.56 + 0.3148 ℓ

STEEL SCHEDULE								
LOCATION	MARK	SIZE	QUAN.	LENGTH	TYPE	A	B	TOTAL FT.
Floor Slab & Walls	1	4		1'-9"	2	0'-9"	1'-0"	
Walls	2	4			St.			
Floor Slab & Walls	3	4	-	4'-0"	2	1'-0"	3'-0"	
Headwall	4	4	4		St.			
Sidewalls	5	4			St.			
Sidewalls	6	4	6		St.			
Center Post	7	4	6	4'-0"	2	1'-0"	3'-0"	24'-0"

QUANTITIES

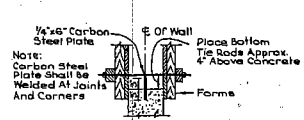
Reinforcing Steel #4 Bars _____ Lin. Ft. _____ Lbs.

Wt. Of Steel = Lin. Ft. x .668 Lbs. Per Lin. Ft.

QUANTITIES FOR POST
0.18 Cu. Yds. Of Concrete

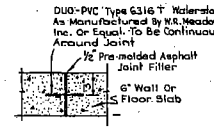
QUANTITIES FOR TROUGH	
BOTTOM WIDTH OF TROUGH (W) IN-FEET	VOLUME OF CONCRETE IN CU. YDS. PER LIN. FT. OF TROUGH INLET
1	0.0740
2	0.0925
3	0.1111
4	0.1296
5	0.1481
6	0.1666
7	0.1852

NOTE:
Structure Is Symmetrical About ℄
Chamfer All Exposed Edges ¾"



NOTE:
Carbon Steel Plate Shall Be Welded At Joints And Corners

DETAILS OF PLATE CONSTRUCTION JOINT



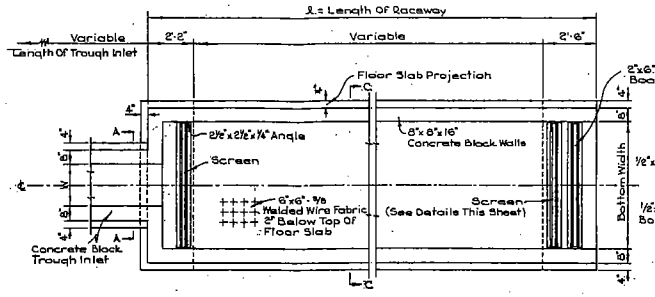
DETAILS OF
WATERSTOP EXPANSION JOINT
NOTE: Waterstop Expansion Joints Shall Be Spaced A Maximum Of 20'-0" Apart

DETAILS OF R.C. TROUT RACEWAY

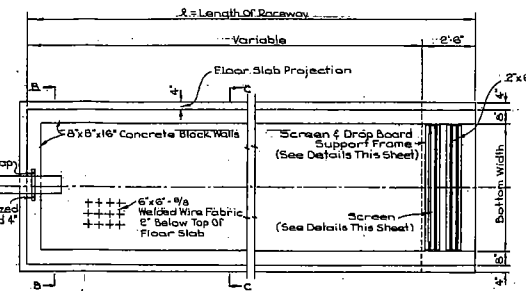
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed C.N. Martin & D.M. McGill 2-65
Drawn N.T. Jones 2-67
Traced
Checked

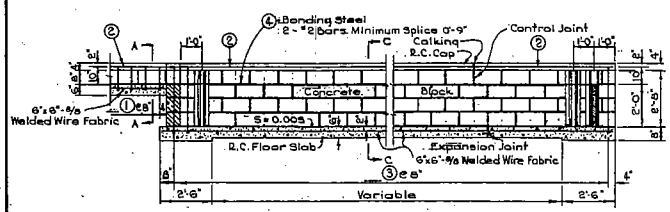
Approved
Title STATE CONSERVATIONIST
Title
Scale
Drawing No.
No. M7-N-18746



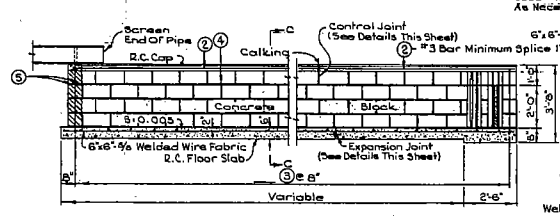
PLAN
SHOWING TROUGH INLET



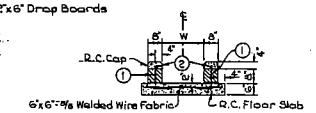
PLAN
SHOWING PIPE INLET



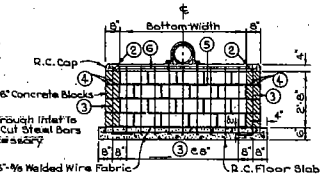
SECTION ALONG ℄
SHOWING TROUGH INLET



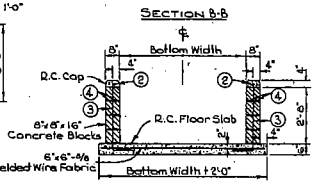
SECTION ALONG ℄
SHOWING PIPE INLET



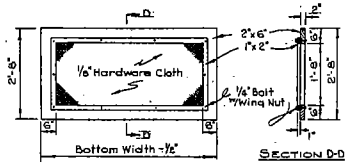
SECTION A-A



SECTION B-B

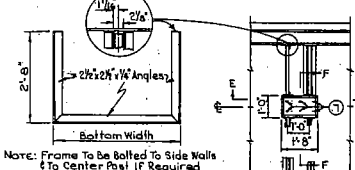


SECTION B-B



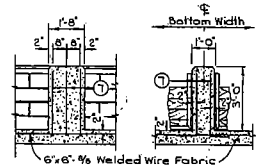
SECTION D-D

DETAILS OF SCREEN



Note: Frame To Be Bolted To Side Walls & To Center Post If Required

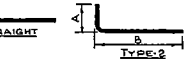
DETAILS OF SUPPORT FRAME REQUIRED.



Note: When Bottom Width Exceeds 6'-0" - A Reinforced Concrete Post Shall Be Placed In The Center Of The Raceway At All Screen & Drop Board Sections

DETAILS OF REINFORCED CONCRETE POST

BAR TYPES



Note: Minimum Radius Of All Bends To Be 4 Times Bar Diameter.

ISOMETRIC VIEW
SHOWING PIPE INLET

QUANTITIES FOR RACEWAY FLOOR	
BOTTOM WIDTH IN FEET	VOLUME OF CONCRETE IN CU. YDS. WHEN ℓ = LENGTH OF RACEWAY IN FT.
4'-0"	.23 x .1111 ℓ
6'-0"	.30 x .1481 ℓ
8'-0"	.37 x .1852 ℓ
10'-0"	.44 x .2222 ℓ

Each Side Of Raceway Has 12 Blocks Per 4' Length
Concrete Cap For Blocks = 0.0329 Cu.Yds. Per 4' Length
Concrete To Fill Cores = 0.111 Cu. Yds. Per 4' Length

Concrete For Center Post = 0.18 Cu. Yds (Each)

Structure Is Symmetrical About ℄
Chamfer All Exposed Edges ¾"

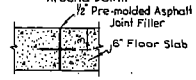
STEEL SCHEDULE								
LOCATION	MARK	SIZE	QUAN.	LENGTH	TYPE	A	B	TOTAL FT.
Floor Slab & Walls	1	3		1'-9"	2	0'-9"	1'-0"	
R.C. Cap	2	3			St.			
Floor Slab & Walls	3	3		4'-0"	2	1'-0"	3'-0"	
Walls	4	2			St.			
Headwall	5	2			St.			
Headwall - R.C.Cap	6	3			St.			
Center Post	7	3	6	4'-0"	2	1'-0"	3'-0"	24'-0"

QUANTITIES
Reinforcing Steel "2" Bars _____ Lin. Ft. _____ Lbs.
Reinforcing Steel "3" Bars _____ Lin. Ft. _____ Lbs.
Wt. Of "2" Steel = Lin. Ft. x .167 Lbs. Per Lin. Ft.
Wt. Of "3" Steel = Lin. Ft. x .376 Lbs. Per Lin. Ft.

QUANTITIES FOR TROUGH	
BOTTOM WIDTH OF TROUGH (W) IN FEET	VOLUME OF CONCRETE PER LINEAR FOOT OF TROUGH INLET
1	0.0556
2	0.0741
3	0.0926
4	0.1111
5	0.1296
6	0.1481
7	0.1667

Each Side Has 3 Blocks Per 4' Length
Concrete Cap For Blocks = 0.0329 Cu.Yds. Per 4' Length
Concrete To Fill Cores = 0.0123 Cu.Yds. Per 4' Length

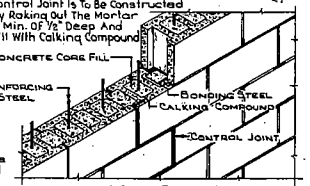
DUO-PVC Type G316T Waterstop As Manufactured By W.R. Meadows Inc. Or Equal To Be Continuous Around Joint.



DETAILS OF WATERSTOP EXPANSION JOINT

Note: Waterstop Expansion Joints & Concrete Block Control Joints Shall Be Spaced A Maximum Of 20'-0" Apart

Note
Control Joint Is To Be Constructed By Raking Out The Mortar A Min. Of ½" Deep And Fill With Calking Compound



WALL DETAIL
SHOWING CONTROL JOINT

DETAILS OF CONCRETE BLOCK RACEWAY.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed C.N. Martin & D.M. McGill 2-65
Drawn W.T. Jones 2-65
Traced
Checked
Approved by [signature] Wiley
Title STATE CONSERVATION ENGINEER
Title
Sheet
No. of
Drawing No. M7-O-18747

Notes:
1. Exposed concrete edges shall be chamfered 3/4 inch or rounded.

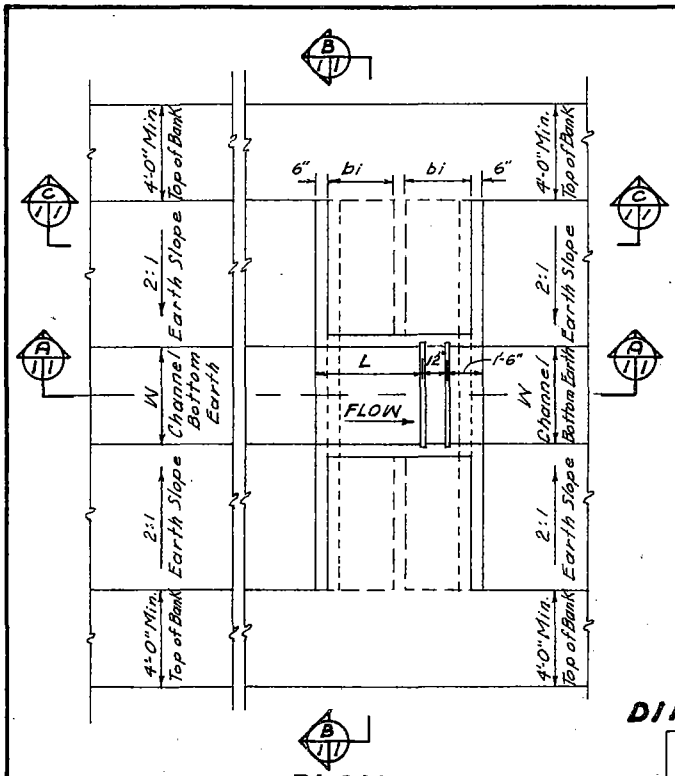
2. Reinforcing bar spacing is center to center.

3. The reinforcing steel mat shall be positioned in the center of the section.

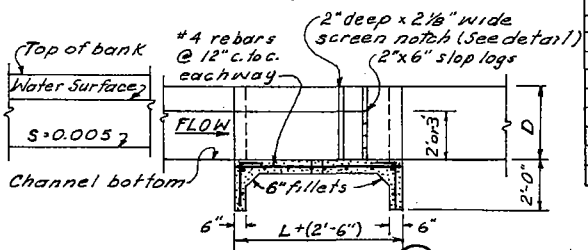
4. Reinforcing bars shall be continous or spliced from floor and walls into adjacent floors, walls and footings.

5. Bar splices shall be staggered with bars lapped at least 15 inches.

6. Concrete shall have a minimum compressive strength at twenty-eight (28) days of 3000 p.s.i. Air-entraining admixture shall be used and the air content shall be between three (3) and six (6) percent of the volume of the concrete. Portland cement shall be used and shall meet the requirements of ASTM Designation C-150 for Type II.



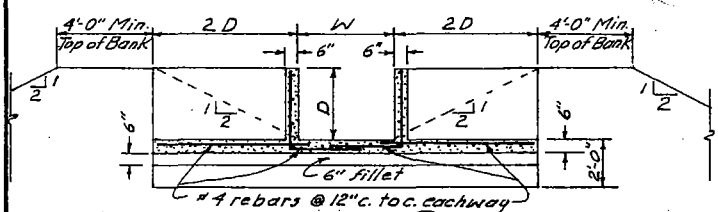
PLAN



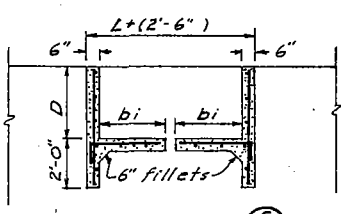
SECTION

DIMENSION AND QUANTITY TABLE

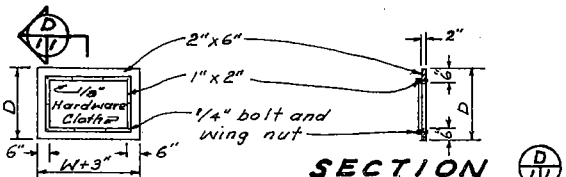
Flow Depth ft.	Width (W) ft.	Trough Depth (D) ft.	Apron Length (L) ft.	Footing Width (bi) ft.	Concrete Volume cu. yds.
2	3	3	4.5	2.75	4.81
2	4	3	4.5	2.75	5.01
2	6	3	6.0	2.75	5.76
2	8	3	8.0	2.75	6.76
2	10	3	10.0	2.75	7.91
3	4	4	5.5	3.25	7.53
3	6	4	6.0	3.25	8.09
3	8	4	8.0	3.25	9.17
3	10	4	10.0	3.25	10.39



SECTION

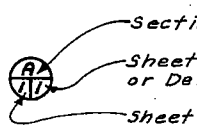


SECTION



SECTION

DETAILS OF SCREEN



No Scale

DETAILS OF CONCRETE CONTROL-EARTH TROUT RACEWAY

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date		
Designed CRH	5-67	Approved by	
Drawn CRH	5-67	Title State Conservation Engr.	
Traced		Title State Biologist	
Checked RDM	5-67	Sheet No / of	Drawing No. M7-0-18748-L